Proton-Proton Chain Activity

1. Access and experiment with the Proton-Proton Chain Simulator (source: Astronomy Education at the University of Nebraska-Lincoln). Complete the following table.

Object	Symbol used in animation	Definition/description
proton	blue ball	positively charged particle in the nucleus of an atom
neutron	red ball	neutrally charged particle in the nucleus of an atom
positron	smaller gold ball	identical to an electron, but with a positive charge, also known as an antielectron
gamma ray	blue wavy line	electromagnetic radiation with very high frequency and very high energy
neutrino	red dotted line	electrically neutral, weakly interacting elementary subatomic particle

2. What is the proton-proton chain?

   The proton–proton chain reaction is one of several fusion reactions in stars which convert hydrogen to helium.

3. The reaction can occur in several different ways, designated by PP I, PP II, and PP III. What percent of the reactions are PP I?

   From the chart above, 69%.

4. What percent of the reactions are PP II? Hint: you will need to convert both the percentages leading to PP II branch, multiply them, and convert the result to a percent.

   $31\% = 0.31$ $99.7\% = 0.997$ $0.31 \times 0.997 = 0.30907 = 30.907\%$

5. What percent of the reactions are PP III? Hint: you will need to convert both the percentages leading to PP III branch, multiply them, and convert the result to a percent.

   $31\% = 0.31$ $0.3\% = 0.003$ $0.31 \times 0.003 = 9.3 \times 10^{-4} = 0.00093 = 0.093\%$

6. Each of the reactions also produces energy. How much energy is produced in the entire process? Where does that energy go?

   About 98% of the energy is converted into kinetic energy, and neutrinos carry off the remaining 2%.

7. How many tons of hydrogen are converted to how many tons of helium each second in the Sun?

   6.0×10^{11} kg.